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COMPARISON OF RADIOSENSITIVITY IN VARIOUS STRAINS OF DROSOPHILA MELANOGASTER

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COMPARISON OF RADIOSENSITIVITY IN VARIOUS STRAINS OF

DROSOPHILA MELANOGASTER - Translation of:

Sravnitel'noye Izucheniye Radiochuvstvitel'nosti Razlichnykh Liniy

Drosophila melanogaster

I. Ye. Vorobtsova

Extensive data are now available on the comparative radioresistance of animals belonging to different orders, genera, species, and strains. It is apparent, however, that any conclusion as to the presence or absence of a relationship between the general radioresistance of an organism and the radiosensitivity of its hereditary material would be particularly convincing if based on data pertaining to closely related organisms, e.g.., those belonging to different strains of the same species. Comparative studies of general radioresistance in those species of animals in which genetic strains have already been created would seem to be of the greatest interest in this connection. Examples of such species are the mouse and Drosophila. A large number of investigations have dealt with interstrain differences in the radioresistance of mice, but despite the suitability of Drosophila as a subject for such investigations (many different strains, possibility of experimenting on a vast amount of material, refined techniques for evaluating the genetic effect of ionizing radiation, etc), none have as yet been conducted.

This report presents results of a study of radioresistance in a variety of Drosophila strains.

Material and Methods

Radioresistance was compared in seven strains of wild-type Drosophila melanogaster. Five- to six-day-old males were exposed. A RUM-7 apparatus was used under the following conditions: voltage - 50 kv, current - 10 ma, focal distance - 75 mm, without filter, without tube, dose rate - 34,185 r/min, dose - 100,000 r.

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Results of pilot experiments with doses of 50, 100, 200, 300, 400, and 500 kr showed 100 kr to be the most satisfactory dose for the purpose of the investigation; with this dose all the flies lived long enough after irradiating so that comparison of survival times was possible for the different strains.

Following exposure, the flies were kept at 25°C. The nutrient medium was changed every other day. Dead individuals were counted daily until the last fly died. A control was run simultaneously with the experiment. The mean survival time and number of flies that died each day served as indicators of radioresistance.

Results and Discussion

The mean survival times of irradiated flies from different strains are given in Table 1. The seven strains can be divided into two groups: one relatively radioresistant (Magarach, RSh, Inozemtsevo, Sh-15) and the other relatively radiosensitive (Tsentrospirt-1, 72, R8-6). Analysis of these data showed that the differences between mean survival times of the two groups of strains were significant, while differences within the groups were slight and not significant.

These strain differences in radiosensitivity cannot, in our opinion, be ascribed to the differences in vitality of individuals before irradiation, since the mean survival times of different strains in the control (Table 2) does not show a significant positive correlation with the mean survival time of experimental flies ($r = 0.03$, while the table requires 0.652 for significance at the 5% level), although there were reliable differences in several strains.

Evidence that differences in mean survival time of irradiated flies reflect differences in radiosensitivity is convincing if we compare the numbers of irradiated and control flies that died each day. Analysis of these data for all the irradiated samples showed that the death rate of radioresistant strains was lower than that of radiosensitive strains (probability of differences $P = 0.99$).

The death rate patterns for flies of different strains (Fig. 1) were generally similar. Deaths rose relatively slowly prior to a certain day (differing from strain to strain); then the death rate increased much more rapidly, tapering off again as the number of dead approached 100%. The curves have two bends, the S-shape indicating that they are cumulative (characteristic) curves reflecting the distribution of individual sensitivity to radiation in the samples. However, this assumption proved to be incorrect, because after appropriate analysis of the data the curve did not straighten out completely, the first point of inflection remaining where it was. It seems to us that this suggests that the curves in question reflect not so much individual variations in radiosensitivity as differences in the processes responsible for the death

Table 1. Average duration of life of exposed males of various Drosophila melanogaster (in days)

Strain	Sample I		Sample II		Sample III		Sample IV		Sample V		Sample VI		Comb. mean survival time for all samp.
	No. of flies	Mean surv. time	No. of flies	Mean surv. time	No. of flies	Mean surv. time	No. of flies	Mean surv.	No. of flies	Mean surv.	No. of flies	Mean surv. time	
RSh							500	16,6±0,14	400	17,3±0,17	610	15,7±0,11	16,5±0,47
Magarach	515	12,6±0,12	530	10,0±0,16	600	15,8±0,12	500	14,1±0,12	400	16,0±0,18	680	15,1±0,15	16,2±0,94
Inozemtsevo			450	19,7±0,18	550	15,5±0,16	500	13,2±0,16	580	15,8±0,16	740	14,2±0,16	15,7±1,11
Sh-15							500	14,6±0,12	500	16,9±0,13	620	14,1±0,09	15,3±0,87
Tsentrospirt-1	325	6,8±0,18	530	14,1±0,15	465	13,3±0,16	370	10,2±0,13	600	13,6±0,14	660	12,2±0,13	12,7±0,68
72	550	11,5±0,09	524	11,9±0,13					463	11,6±0,49			11,7±0,12
R8-6							500	11,7±0,11	270	11,4±0,25	900	11,8±0,09	11,6±0,12

Note: Commas in tables 1 and 2 represent decimal points.

Table 2. Average lifetime of unexposed males of Drosophila melanogaster (in days)

Strain	Sample II		Sample III		Sample IV		Sample V		Sample VI	
	No. flies	Mean survival time	No. flies	Mean survival time	No. flies	Mean survival time	No. flies	Mean survival time	No. flies	Mean survival time
RSh					400	43,0±0,71	300	42,0±0,77	300	38,6±0,68
Magarach	550	36,8±0,26	400	40,6±0,62	400	41,8±0,61	300	41,2±0,71	400	35,8±0,87
Inozemtsevo	500	32,1±0,43	400	37,5±0,67	400	33,4±0,51	300	31,5±0,48	400	32,5±0,62
Sh-15					300	44,2±0,86	300	45,3±0,91	400	43,5±0,76
Tsentro-spirt-1	500	27,5±0,35	400	36,0±0,56	400	40,0±0,70	300	33,3±0,78	400	36,4±0,94
72	550	28,9±0,34					500	29,2±0,21		
R9-6					300	39,0±0,61	400	42,1±0,51	400	42,7±0,55

at different times after exposure. Comparison of mean survival times for irradiated individuals of different strains (the objective indicator of their relative radiosensitivity) with the death rate at different intervals after exposure favors this assumption. The indicator for death rate at different intervals after exposure (the portions of the curve before and after the first point of inflection) was the regression coefficient for the percentage of flies that died each day, corrected against the control on the day after exposure. Table 3 gives the regression coefficients for the first and second portions of the curve separately, as calculated for all the replications together, and mean survival times for the seven strains (the regression coefficients are reliable: P 0.95). These data show an inverse relationship between mean survival time and death rate in the first postexposure period, as determined from the regression coefficient, while the death rate in the second period is apparently independent of the mean survival time. The correlation coefficients between the mean survival times of the irradiated flies and the regression coefficient were calculated for the first and second portions of the curve. Here actual survival times for each strain averaged from all the replications were entered into the correlation grid along with the corresponding regression coefficients. The correlation coefficients were 0.8 for the first postexposure period and 0.2 for the second (with a tabular value for r of 0.482 at the 5% level of significance).

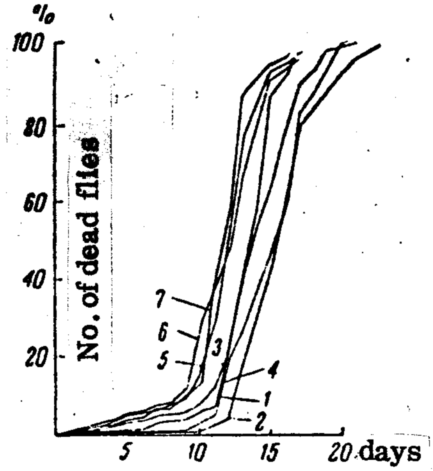

Fig. 1. Death rates for different strains of flies after exposure to 100 kr.

Strains: 1 - RSh; 2 - Magarach; 3 - Inozemtsevo; 4 - Sh-15; 5 - Tsentrospirt-1; 6 - 72; 7 - P8-6

No firm conclusions can be drawn from our data concerning the nature of the different processes leading to the death of individuals during the first and second postexposure periods. It is clear, however, that the death rate during the first period reflects fairly objectively differences in radiosensitivity of the strains tested. These differences were reflected in the death rates (estimated from the regression coefficient) and in the length of the first period for the different strains studied (Fig. 2). The correlation coefficient for mean survival time and duration of the first period shows that the connection between these values is quite genuine ($r = 0.66$, while the table shows $r = 0.52$ at the 1% level).

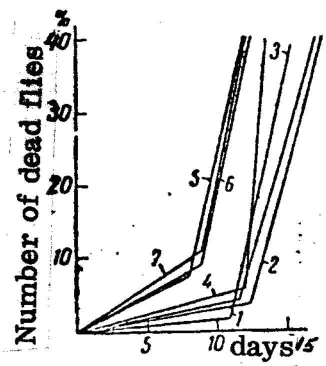

Fig. 2. Regression curves for percentages of dead flies (corrected against the control) for each day after exposure. Strains are the same as in Fig. 1

Table 3. Comparison of the mean survival times for different strains of irradiated mice and regression coefficients for the first and second regions of the curve (Fig. 1)

Strain	Mean survival time, days	Regression factors	
		1st portion	2nd portion
RSh	16.5	0.034	8.77
Magarach	16.2	0.156	6.49
Inozemtsevo	15.7	0.201	7.64
Sh-15	15.3	0.345	9.51
Tsentrospirt-1	12.7	0.760	6.17
72	11.7	0.806	8.71
P8-6	11.6	0.914	8.01

The differences in the death rates during the second postexposure period do not reflect relative radioresistance of the various strains of flies. These differences may have been due, in our opinion, to differences in homogeneity of the samples with respect to sensitivity to radiation. It will be noted that the actual picture was clearly different during these two periods. During the first period the picture outwardly resembled that for the unirradiated flies (the irradiated flies remained mobile, death occurred somewhat "suddenly"). During the second period the changes were characteristic (the flies became sluggish, motionless; they clung to the medium; swelling of the venter was common).

The existence of two death periods following irradiation was noted by L. K. Lozina-Lozinskiy and S. N. Aleksandrov in infusorians (1). However, differences in the radioresistance of infusorians from different populations were also manifested only during the first postexposure period.

It is of interest to examine the data of our experiments (for one of the strains) concerning the duration of the first postexposure period after different doses. It is evident from Fig. 3 that this period became shorter as the dose was increased. Similar changes in the death rate for individuals exposed to different doses were observed by N. I. Shapiro and N. I. Nuzhdin in mice (2), where there was no doubt as to the existence of radiation sickness as a syndrome of definite pathologic processes. The authors point out that as the dose was increased, the distribution of deaths with time shifted to periods ever closer to the moment of exposure. We had the impression that irradiated Drosophila developed a peculiar kind of "radiation sickness" characterized by the existence of different periods.

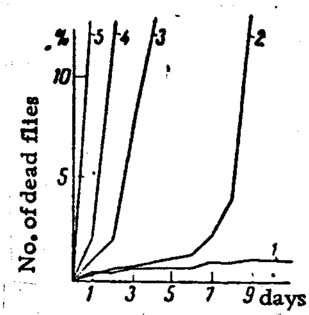

Fig. 3. Death rates for a strain of flies after exposure to different doses of radiation. 1 - 50 kr; 2 - 100 kr; 3 - 200 kr; 4 - 300 kr; 5 - 400 kr.

Thus, interstrain differences in radiosensitivity, as found in several investigations on mice, exist in Drosophila as well. The high positive correlation discovered in all the strains tested between general radiosensitivity and rate at which the flies died during the first postexposure period apparently renders it possible to shorten the length of the observation period needed for objective evaluation of the relative radiosensitivity of the strains. The method of evaluating radiosensitivity from the death rate of individuals during the first postexposure period (until the day when they begin to die off very rapidly) may, in our opinion, be even more accurate than the method involving determination of the mean survival time, because the shorter observation period limits the possibility of distortions due to external factors.

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